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MEMO

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From:
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Date:
March 26, 2014

ARCADIS Project No.:
B0009968.0000.00001

Subject:
Conceptual Fish and Crab Sampling Plan for Lower Passaic River Study Area

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This technical memorandum (memo) presents a proposed plan and approach for the collection of fish and crab tissue data in the Lower Passaic River Study Area (LPRSA) in 2014. The LPRSA includes the tidal portion of the Passaic River from its confluence with Newark Bay upstream to the Dundee Dam—approximately 17 river miles (Figure 1). In June 2007, a group of 73 potentially responsible parties, named the Cooperating Parties Group (CPG), entered into an Administrative Order on Consent (AOC) with U.S. Environmental Protection Agency (USEPA) to conduct the Comprehensive Environmental Response, Compensation and Liability Act – Water Resources Development Act Remedial Investigation/Feasibility Study for the LPRSA (USEPA 2007). Subsequent to the CPG entering into the 2007 AOC, USEPA and other agencies developed a draft Focused Feasibility Study (FFS) to evaluate the need to undertake an early action in the lower 8 miles of the river. This FFS process is ongoing, with a subsequent report set to be released by USEPA in the near future. This memo has been prepared to describe a data collection program to fill a known data gap that would inform the pending FFS. It presents a conceptual sampling plan to collect additional fish and crab tissue data for the primary chemicals of concern (COCs) in order to conduct statistical trends analysis for biota tissue chemistry data in the LPRSA. The need and justification for such a program is described herein, along with the details of a sampling program that can be implemented in 2014.

Background

Nearly all of the fish and crab tissue data available for the LPRSA were collected during only two sampling periods: 1999-2001 (Tierra Solutions, Inc. [Tierra]/USEPA) and 2009/2010 (CPG/USEPA). For each of these sampling events/periods, the species and spatial area of the river that was sampled differed. In 1999-2001, Tierra sampled the lower 6 miles of the LPRSA and collected primarily marine/estuarine species. In 2009/2010, the CPG focused primarily on the upper 11 miles of the LPRSA and collected mostly freshwater species (e.g., catfish). The CPG collected some estuarine data from the lower 6 miles of the LPRSA in 2009/2010 for three of the edible fish/shellfish species that were sampled by Tierra in 1999-2001: white perch (*Morone americana*), a resident fish species; American eel (*Anguilla rostrata*), a migratory fish species; and blue crab (*Callinectes sapidus*), a mostly resident shellfish species.

Because there are limited tissue data from only two time periods, some of which lack spatial overlap, it is not possible to conduct a defensible statistically-based evaluation of potential trends in chemical concentrations. However, in looking at the averages for the LPRSA as a whole and the lower 8 miles only for these species[1], it appears that there may be a downward trend in the overall concentrations of both TCDD and PCBs. Figures 2 and 3 show blue crab TCDD and total PCB data by river mile and time period for the LPRSA. Data for blue crab are the most robust in terms of sample numbers and spatial overlap between the 1999-2001 and 2009/2010 sampling events. Figures 2 and 3 appear to indicate that both TCDD and PCB concentrations are generally lower in 2009/2010 than they were in 1999-2001; however, a third dataset is needed to confirm the trend.

Determination of whether a statistically significant trend in fish and crab tissue data does or does not exist is critical to drawing any conclusions regarding future risks in the river, and for consideration related to any remedial actions. The present datasets are insufficient for this purpose. For this reason, the release of the FFS with proposed risk-based remedial actions that are primarily focused on reductions in COCs in fish and crab tissue in the LPRSA is premature. Instead, the FFS should be postponed until another biota tissue dataset can be collected, and a statistical evaluation of any trends is performed. A trend analysis will require more tissue data to be collected for the same species and primary COCs as were collected in both the previous time periods (1999-2001 and 2009/2010) throughout the LPRSA. Assuming these data are collected this calendar year, the dataset would represent additional fish tissue concentrations 4 to 5 years newer than the latest dataset and provide important information about potential spatial and temporal trends in tissue concentrations. The conceptual plan for fish and crab sampling in the LPRSA is presented in the remainder of this memo. Because we have the collective knowledge regarding successful fishing/crabbing methods and locations, and related Quality Assurance Project Plans (QAPPs) and reports from the previous two LPRSA programs, it will be fairly straightforward to develop a detailed QAPP and

[1] The summary statistics for concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and total polychlorinated biphenyls (PCBs) in these species are provided in Table1 for the entire 17-miles of the LPRSA, and Table 2 for river mile (RM) 0 to RM 8 only.

related documentation for this sampling plan, in order to expedite its approval by USEPA and its Partner Agencies, and the mobilization for and implementation of the sampling program in 2014.

General Sampling Design

The objective of this sampling plan is to collect fish and crab tissue from the LPRSA to evaluate potential statistical trends in COC concentrations from data representing different timeframes. In addition to evaluating potential spatial and temporal trends in COCs, human health risk, ecological risk, and possible remedial alternatives within the LPRSA, will also be evaluated using the new data. This tissue sampling event can be conducted any time between the late spring and early fall of 2014. A goal of this program is to maintain consistency in the types of species/tissue types that have been collected/analyzed in the past programs, and the (successful) sampling approaches used to obtain the historic samples.

The tissue sampling and analysis program proposed herein includes targeting several species of fish and shellfish that were sampled in the previous two programs. The target species were chosen based on their relative importance to assessing potential human health and ecological risk, and their relative abundance in the LPRSA (i.e., those species that have been shown to be most widespread and abundant in the river during the two historical sampling events). Target species include catfish, a benthic omnivore; white perch, an epibenthic/pelagic invertivore; American eel, a demersal piscivore; and blue crab, a benthic omnivore. These species have been collected throughout the LPRSA in substantial numbers and represent species consumed by both humans and wildlife. Tissue samples will consist of composites of multiple fish or crabs [2] of the same species to provide sufficient tissue mass for chemical analysis and for consistency with the previous USEPA-approved 1999-2001 Ecological Sampling Program (ESP; Tierra 1999) and the CPG's Tissue Sampling for the entire 17-mile stretch of the river (Windward 2009a,b).

The general sampling design divides the LPRSA into two major zones according to surface water salinity: the estuarine zone (RM 0 to RM 8) and the freshwater zone (RM 8 to RM 17.4). Each zone is subdivided into 2-mile river reaches and sampling locations are allocated among these reaches. Sampling locations will be located within each 2-mile river reach in areas of known or likely habitat based on results of the 2010 field reconnaissance (Windward 2013) and prior field sampling events (Tierra 1999; Windward 2010, 2011). This will ensure that tissue samples targeted in each zone are collected spatially throughout the zone. Figures 4a and 4b depict previous samples collected from the estuarine zone (Figure 4a) and freshwater zone (Figure 4b), and show the breakdown of the sampling reaches within each zone. A breakdown of the major zones, reaches and river miles is as follows:

[2] Composite tissue sampling provides a cost-effective approach for developing an estimate of the mean concentration of chemicals in tissue (USEPA 2002), is consistent with the human health risk assessment data use objective of estimating mean concentrations in tissue consumed by humans over a long-term period of exposure (USEPA 1989a, 1989b, 2000), ensures sufficient tissue mass for the program's extensive analytical requirements, and provides comparability with the sampling that was conducted under the ESP and CPG programs.

Zone	Reach	River Mile
Estuarine	1	0 – 2
	2	2 – 4
	3	4 – 6
	4	6 – 8
Freshwater	5	8 – 10
	6	10 – 12
	7	12 – 14
	8	14 –17.4

The target sampling area for all species will focus on localized habitat areas (i.e., areas with a radius of approximately 100 ft). At least two target sampling locations will be sampled in each reach based on the locations identified by CPG and so that sampling locations are distributed evenly per zone; however, additional sampling areas may be identified in the field in order to collect sufficient numbers of fish to meet the tissue mass requirements. Composites will be created for each target tissue type and analyzed separately. The number of individuals in a single composite will be based on analytical mass requirements.

A full suite of chemical (COC) analyses will be conducted on the tissue samples. These include metals[3] (including mercury and methylmercury), organochlorine pesticides (excluding toxaphene), butyltins, PCBs (Aroclors and 209 individual congeners), dioxins/furans, semi-volatile organic compounds, polycyclic aromatic hydrocarbons (PAHs; excluding alkylated PAHs), percent moisture, and lipid content. Herbicides and volatile organic compounds (VOCs) will not be analyzed. All analyses will have low level detection limits, which will be identified in advance in the (QAPP).

Target tissue types for the human health risk assessment (HHRA) include fish fillets, edible crab muscle, and hepatopancreas composite samples. Target tissue types for the ecological risk assessment (ERA) include whole-body fish and whole-body crab (all soft parts without shell). To meet the needs of both risk assessments with one sampling event, catfish fillets will be analyzed separately from the remaining tissue (carcass). Catfish fillet chemical concentrations then will be combined mathematically (proportionally to the average weight of the species) with carcass chemical concentrations to compute whole-body concentrations. This is consistent with the USEPA-approved approach used in the 2009/2010 CPG sampling program and will reduce the number of catfish samples required for analysis. Because white

[3] Metals analysis will include the following metals: aluminum, antimony, arsenic (total and inorganic), barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, titanium, vanadium, zinc.

perch and American eel are anticipated to be more abundant throughout the river than catfish, separate fillet and whole-body composite samples will be analyzed.

A maximum number of sampling attempts per location will be established; however, it may not be possible to collect adequate tissue mass at each specified sampling location to constitute a full analytical sample. In such cases, Tierra will work closely with USEPA during sampling to make decisions regarding compositing. If insufficient tissue has been collected after the maximum number of attempts, the target area will be expanded, or alternative species may be collected, depending on the fish catch. Tissue from different species will not be combined. After additional attempts have been exhausted, a chemical prioritization scheme will be employed for the analysis of the volume of tissue collected. Some sampling locations may need to be relocated or abandoned.

Estimates of Sample Size

When sampling an aquatic system the size of the LPRSA, reasonable estimates of the distribution of chemical concentrations in fish and shellfish tissue are needed to estimate potential risks to wildlife and humans that may consume them. To determine the number of samples sufficient for the sampling objectives, ARCADIS conducted statistical evaluations using the existing fish and shellfish tissue datasets from the 1999-2001 ESP and 2009/2010 CPG tissue sampling programs in the LPRSA.

Sample sizes for each species/tissue type were selected with the following objectives:

- To estimate 95% upper confidence limits on the mean (95UCL) with reasonable precision (i.e., small relative error)

- To have sufficient power to detect differences in the mean when the new dataset is compared to data collected in the two previous time periods (i.e., 1999-2001 and 2009/2010).

For mean estimation, sample sizes can be calculated according to the following formula found in Chapter 8 of the USEPA's ProUCL 5.0 Technical Guidance Document (USEPA 2013):

$$n = Z^2_{1-(\alpha/2)} (\text{standard deviation/difference from true mean})^2 + Z^2_{1-(\alpha/2)}/2$$

where Z is the standard normal deviate that cuts off (1-(α/2))% of the distribution and 1-α/2 is the required confidence interval range. This equation can be modified to calculate sample size using relative error (as fraction of true mean) and coefficient of variation (CV) instead of using actual variance and margin of error (Gilbert 1987). The resulting equation is as follows:

$$n = Z^2_{1-(\alpha/2)} (\text{CV/relative error})^2 + Z^2_{1-(\alpha/2)}/2$$

Sample size estimates were calculated for the range of CVs that have been observed in the existing tissue datasets and a range of relative errors, as provided below:

Sample Size Estimates as a Function of Relative Error and CV

Relative Error	Coefficient of Variation					
	0.25	0.4	0.5	0.6	0.7	0.8
20%	6	13	19	26	35	45
25%	5	9	13	17	23	30
30%	4	7	9	13	17	21
35%	3	5	7	10	13	16

Because CVs for the tissue data are generally less than 0.6, a sample size of 13 will result in 95UCLs with a relative error of 30% or less. The mean differences in concentrations noted between time periods in Tables 1 and 2 are generally in the range of 20 to 30%. Therefore, a sample size of 13 was selected as the minimum sample size for most species and tissue types where a 95UCL could be calculated by zone. The exception to this was for blue crab muscle and hepatopancreas, which tend to show lower CV and can be characterized with a smaller sample size.

Sample Numbers and Rationale

The statistics presented in Tables 1 and 2 provide evidence that tissue concentrations may be decreasing over time in the LPRSA. If such a trend truly exists, it is important that sample sizes be adequate to detect differences in mean concentrations over time. Power (β) is the probability of detecting a statistically significant difference in the mean of two populations at a prescribed Type I[4] error rate (α) when the means are in fact different. Power calculations require assumptions of the true difference in the means between the populations, the size of the sample collected from each population, and the standard deviation of the two populations.

Power calculations for this analysis were performed using SAS 9.3 (SAS Institute 2012) and are based on the observed attributes of the previous tissue datasets for 2,3,7,8-TCDD and total PCBs (sum of 7 Aroclors). Assumptions of the mean difference are based on the observed difference in means between the 1999-2001 ESP dataset and the 2009/2010 CPG dataset for RM 0 to 8. No tissue data are available for RM 8 to17 for the 1999-2001 time period. The standard deviation is assumed to be equal to the observed standard deviation in the 2009/2010 dataset. The power equation can be rearranged to calculate the required sample size of a new sample given the samples collected and α and β are

[4] The Type I error rate is the probability of rejecting a hypothesis when it is in fact true. In this case the Type I error rate refers to the probability of rejecting the hypothesis that two means are equal when in fact they are equal. The Type II error rate is equal to 1-β, and is the probability of accepting a hypothesis when it is false.

specified. The sample size for the first sample is the actual sample size of the 2009/2010 dataset (RM 0 to 8). The sample size for the proposed dataset is calculated to, at a minimum, provide 70% power to detect a difference between means at an alpha = 0.10 using a one-sided two sample t-test. Table 3 provides the results of the power analysis.

The sample size estimates provided in Table 3 represent the sample size necessary for a comparison of data from RM 0-8 only. Since we do not have the data to support a power calculation for a river-wide (i.e., 0-17 miles) analysis, we estimate that using double the sample size would result in adequate power ($\beta > 0.7$) to detect temporal differences. The results of the power analysis indicate that for some species/tissue types a sample size greater than 13 may be needed to provide adequate power to detect a difference at least as small as the difference already observed between the 1999-2001 and 2009/2010 datasets, particularly for whole body blue crab samples. The target sample size for blue crab was increased to 22 to ensure that statistical comparisons for 2,3,7,8-TCDD would have adequate power. For white perch fillet, the power analysis indicates that a sample size of 17 is needed for a RM 0-8 calculation. The sample size for white perch fillet was not increased since a river-wide comparison will have adequate power. Another consideration in assessing sample size requirements is the number of comparisons being made. Since multiple comparisons will be made (i.e., one comparison for every combination of species, tissue type, and chemical constituent), the probability of detecting an overall temporal trend in the river will be much greater than the power of an individual test. Therefore these minimum sample sizes are very conservative.

Based on the power evaluation and considering the sample size estimates as a function of relative error and CV, proposed sample sizes for fish and crab tissue are below.

Feeding Guild	Species	No. of Composite Samples per Tissue Type per Zone	Type of Sample	Total No. of Analytical Samples
Invertivore	white perch[a]	13	skinless fillet	52
		13	whole body	
Benthic omnivore	catfish[b]	13	skinless fillet	26
		13	remaining carcass	
Piscivore	American eel[a]	13	skin-on fillet	52
		13	whole body	
Epibenthic omnivore	blue crab	22	whole body	44
		8	edible muscle	16
		8	hepatopancreas[b]	16
			Total	**206**

Notes:

a. White perch and American eel samples may be analyzed as individual fish or composite samples, depending on size.
b. While white catfish (*Ameiurus catus*) will be targeted, other types of catfish including channel catfish (*Ictalurus punctatus*) and brown bullhead (*Ameiurus nebulosus*) may be considered depending on abundance. Catfish only targeted in the freshwater zone, which is the extent of their range in the LPRSA.
c. From a subset of crabs collected for edible muscle analysis.

Proposed Sampling Methods

Several methods are proposed to collect fish and blue crab throughout the LPRSA, including minnow/eel traps, crab traps, trotlines, and gillnets. While the majority of fish will be captured from the shoal areas near the shoreline, gillnets will also be positioned mid-channel as necessary. Boat and/or backpack electrofishing will be conducted as salinity and conductivity allow, but will likely be restricted to reaches 4 through 8 (RM 6 through 17.4). Bait will vary by method but may include bologna, cheese dough, chicken legs, blood dough, commercially processed blue crab, shrimp, worms, and chicken livers. Additional information on sampling methods will be provided in the standard operating procedures (SOPs). The SOPs and QAPP for this sampling event will be adopted from the comparable documents developed by the CPG for the 2009/2010 sampling program. These will be developed and submitted to USEPA in an expedited manner for review and approval, so that this program can proceed in 2014.

Summary

Fish and shellfish tissue samples will be collected from various locations throughout the LPRSA. A summary of the total number of fish and shellfish samples is presented above and summarized below.

- Blue crabs: A total of 44 whole body blue crab samples will be collected from the LPRSA; 22 crabs will be collected from each zone (estuarine and freshwater) and submitted to the analytical laboratory. Eight additional crab tissue samples will be collected from each zone and will consist of separate samples of edible tissue and hepatopancreas tissue samples.

- White perch: A total of 52 white perch samples will be collected from the LPRSA; 26 white perch samples will be collected from each zone (estuarine and freshwater) and submitted to the analytical laboratory. 13 samples will be submitted as skinless fillets; 13 samples will be submitted as whole body fish. Composite samples will consist of fish smaller than 30 centimeters. Larger fish will be submitted as individual samples.

- American eel: A total of 52 American eel samples will be collected from the LPRSA; 26 American eel samples will be collected from each zone (estuarine and freshwater) and submitted to the analytical laboratory. 13 samples will be submitted as skin-on fillets; 13 samples will be submitted as whole body eels. Composite samples will consist of fish smaller than 30 centimeters. Larger fish will be submitted as individual samples.

- Catfish: White catfish (*Ameiurus catus*) will be the targeted species; however, other types of catfish including channel catfish (*Ictalurus punctatus*) and brown bullhead (*Ameiurus nebulosus*) may be considered depending on abundance. A total of 26 catfish samples will be collected, primarily from the freshwater zone (i.e., RM 8 to 17) of the LPRSA. 13 samples will be submitted to the laboratory as skinless fillets; the remaining skin-on carcass will also be analyzed and used

to derive whole body chemical concentrations. Composite samples will consist of fish smaller than 30 centimeters. Larger fish will be submitted as individual samples.

Overall, this conceptual sampling program is anticipated to provide the additional fish and crab tissue dataset required to evaluate potential statistically significant trends in concentrations of COCs in tissue over time and throughout the LPRSA. These data are also paramount in evaluating ecological and human health risks and possible remedial options as part of the FFS for the LPRSA. This sampling program has been developed taking into consideration prior sampling programs/events, including target species, numbers and locations of previous samples, necessary statistical power, as well as the sampling methods and effort required to capture fish from the LPRSA.

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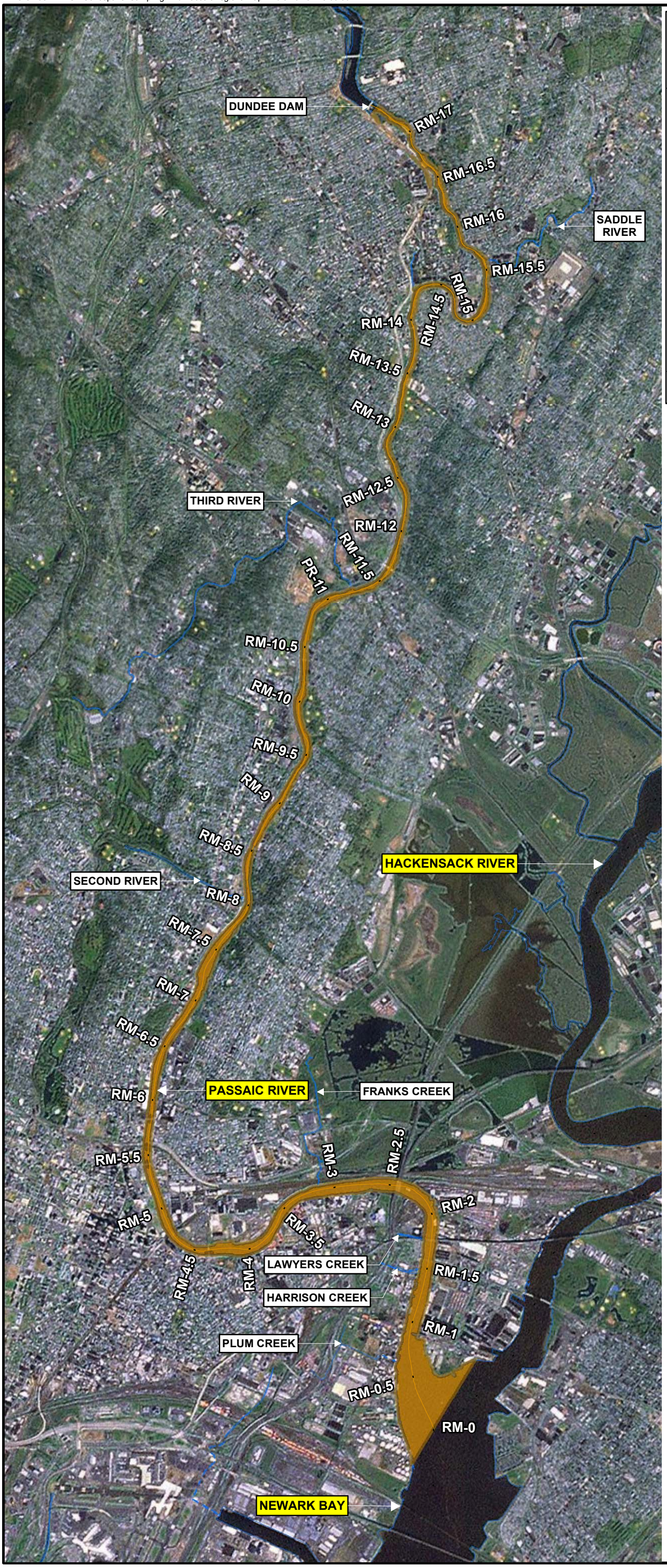
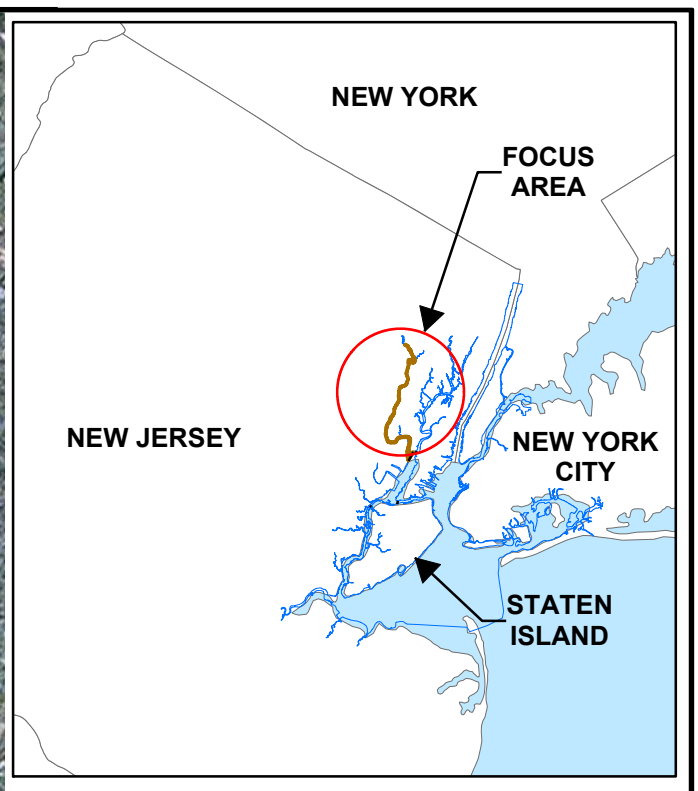




LEGEND:

LPRSA RIVER MILE

LOWER PASSAIC RIVER STUDY AREA

NOTES:

1. BASEMAP INFORMATION FROM NOAA CHARTS 12331, 12333, AND 12337, DATED MAY 4, 1995.
2. 2007 IMAGERY FROM ESRI BING IMAGERY.

0 0.9 1.8 Miles

GRAPHIC SCALE

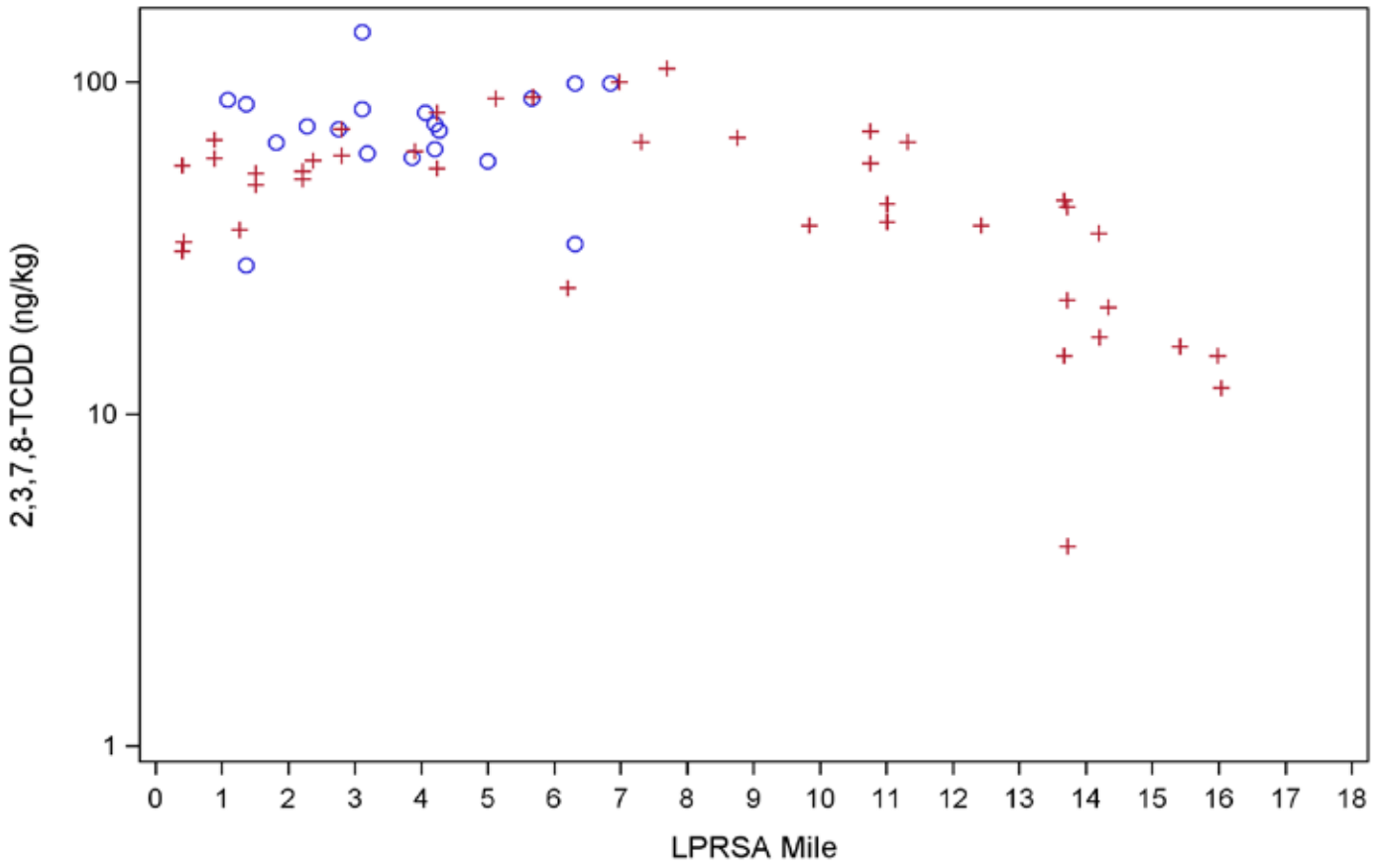
LOWER PASSAIC RIVER STUDY AREA

CONCEPTUAL FISH AND CRAB SAMPLING PLAN

LOWER PASSAIC RIVER STUDY AREA

MARCH 2014

FIGURE **1**



Notes:
LPRSA = Lower Passaic River Study Area
ng = nanogram ; kg = kilogram
TCDD = tetrachloro-*p*-dibenzodioxin

Year of Sampling ○ 1999-2001 + 2009-2010

Lower Passaic River Study Area
Conceptual Fish and Crab Sampling Plan

2,3,7,8-TCDD in Blue Crab (Whole Body)

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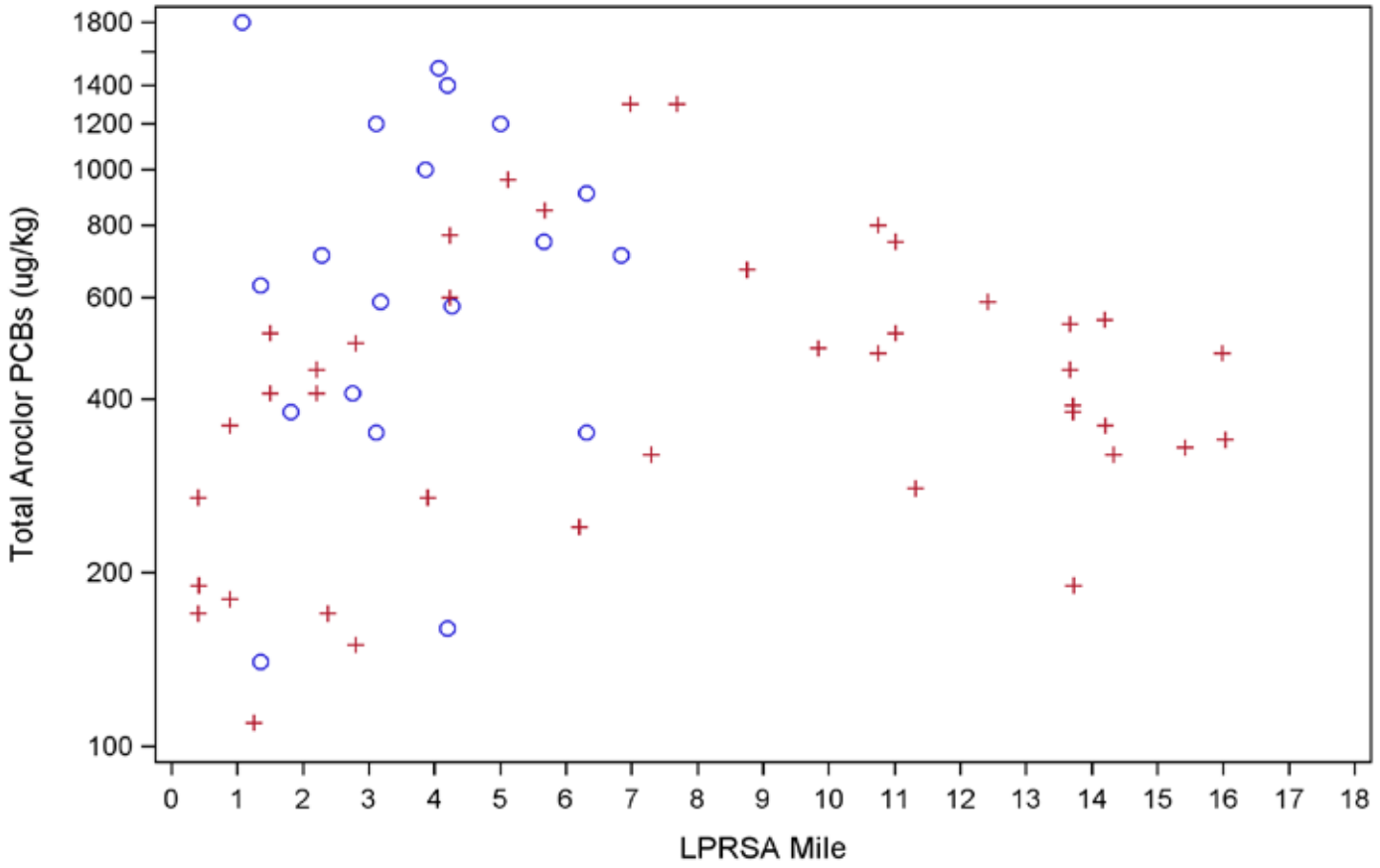
FIGURE
2



Notes:
LPRSA = Lower Passaic River Study Area
µg = microgram ; kg = kilogram
PCB = polychlorinated biphenyl

Year of Sampling ○ 1999-2001 + 2009-2010

Lower Passaic River Study Area
Conceptual Fish and Crab Sampling Plan

Total PCBs (7 Aroclors) in Blue Crab (Whole Body)

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FIGURE
3

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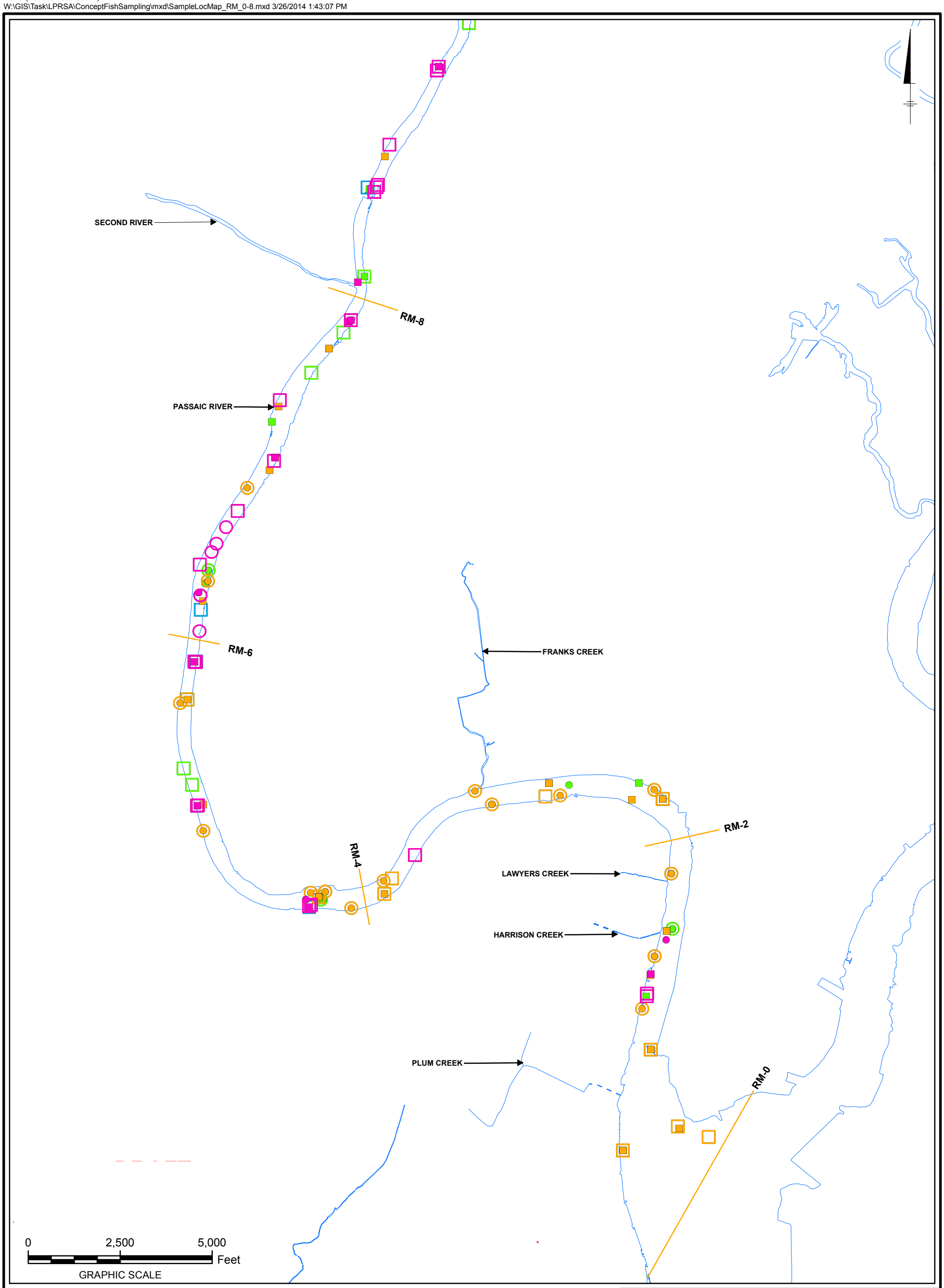

LEGEND:

SAMPLING EVENT
- ● 1999-2001 ESP
- ■ 2009-2010 CPG TISSUE

WHOLE BODY	FILLET OR MUSCLE	
■	▭	AMERICAN EEL
■	▭	BLUE CRAB
■	▭	WHITE PERCH
■	▭	WHITE CATFISH

- PROPOSED SAMPLING REACH
- SHORELINE
- UNDERGROUND TRIBUTARY

NOTES:

1. BLUE CRAB HEPATOPANCREAS SAMPLE LOCATIONS ARE NOT SHOWN.
2. PROPOSED SAMPLING REACHES ARE DEPICTED BY LPRSA RIVER MILES.

LOWER PASSAIC RIVER STUDY AREA

CONCEPTUAL FISH AND CRAB SAMPLING PLAN

PROPOSED SAMPLING REACHES IN THE ESTUARINE ZONE (RM 0 - 8) AND LOCATIONS OF HISTORICAL SAMPLES

MARCH 2014

FIGURE **4a**

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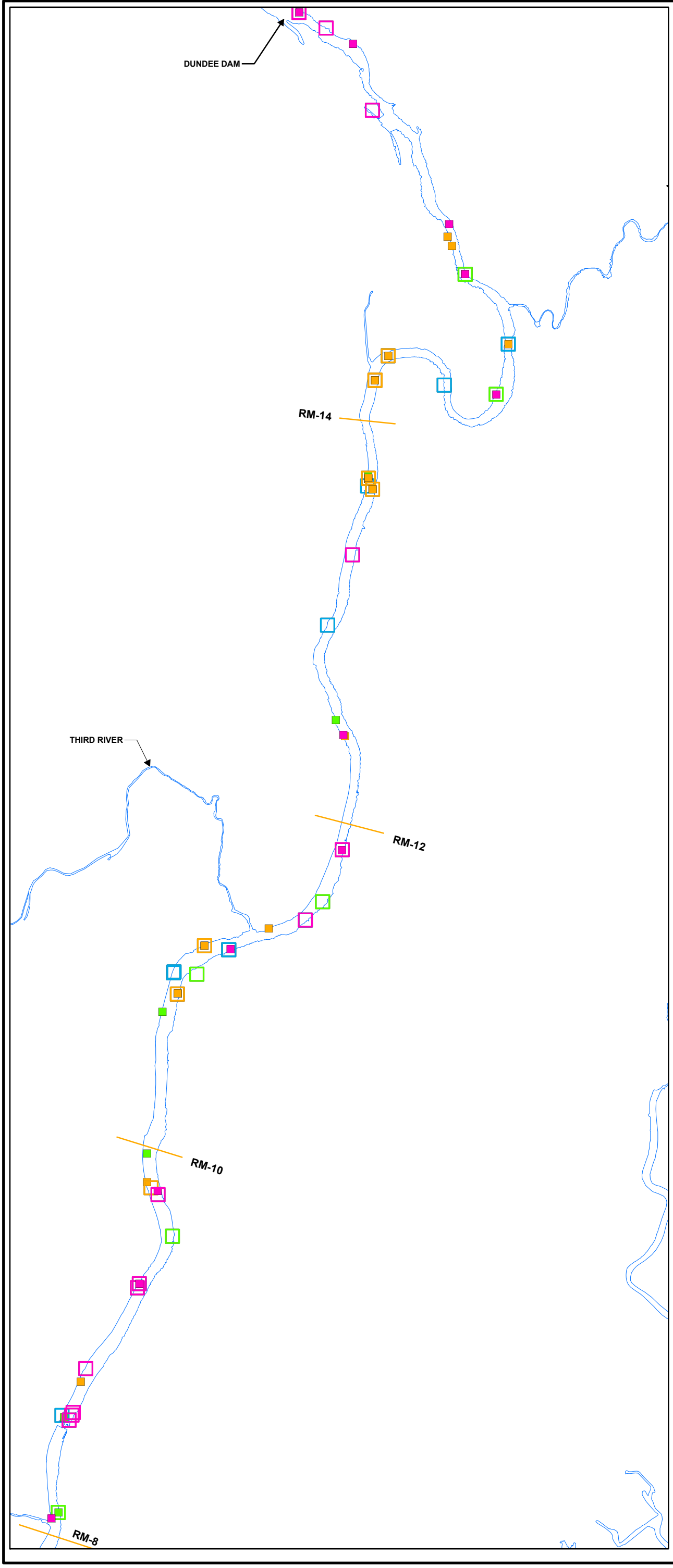

LEGEND:

SAMPLING EVENT
- 1999-2001 ESP
- 2009-2010 CPG TISSUE

WHOLE BODY	FILLET OR MUSCLE	
		AMERICAN EEL
		BLUE CRAB
		WHITE PERCH
		WHITE CATFISH

- PROPOSED SAMPLING REACH
- SHORELINE
- UNDERGROUND TRIBUTARY

NOTES:

1. BLUE CRAB HEPATOPANCREAS SAMPLE LOCATIONS ARE NOT SHOWN.
2. PROPOSED SAMPLING REACHES ARE DEPICTED BY LPRSA RIVER MILES.

0 2,500 5,000 Feet

GRAPHIC SCALE

LOWER PASSAIC RIVER STUDY AREA

CONCEPTUAL FISH AND CRAB SAMPLING PLAN

PROPOSED SAMPLING REACHES IN THE FRESHWATER ZONE (RM 8 - 17) AND LOCATIONS OF HISTORICAL SAMPLES

MARCH 2014

FIGURE **4b**

Table 1. Tissue Concentrations in Selected Species Collected in the Lower Passaic River Study Area (LPRSA) by Sampling Period

Chemical	Species	Tissue Type	Sampling Period	N	Number of Detects	Frequency of Detection	Mean	Standard Deviation	Minimum	Maximum
2,3,7,8-TCDD (ng/kg)	American Eel	Fillet	1999-2001	7	7	100%	21.7	6.49	14.6	32.2
	American Eel	Fillet	2009-2010	32	32	100%	13.5	9.84	0.31	41
	American Eel	Whole Body	1999-2001	6	6	100%	9.7	6.34	4.53	20.6
	American Eel	Whole Body	2009-2010	19	18	95%	16.8	15.0	0.11	47
	Blue Crab	Hepatopancreas	1999-2001	15	15	100%	262	45.0	195	371
	Blue Crab	Hepatopancreas	2009-2010	7	7	100%	143	63.8	41	210
	Blue Crab	Muscle	1999-2001	18	18	100%	17.6	3.94	10.9	22.7
	Blue Crab	Muscle	2009-2010	21	21	100%	7.48	5.65	0.82	20
	Blue Crab	Whole Body (Soft Tissue)	1999-2001	19	19	100%	75.0	24.8	28	141
	Blue Crab	Whole Body (Soft Tissue)	2009-2010	41	41	100%	49.2	25.0	4	110
	White Perch	Fillet	1999-2001	6	6	100%	64.9	22.2	34.4	88.9
	White Perch	Fillet	2009-2010	19	19	100%	41.0	24.1	3.6	99
	White Perch	Whole Body	1999-2001	18	18	100%	212	81.1	73.6	352
	White Perch	Whole Body	2009-2010	19	19	100%	129	71.5	18.0	250
Total PCBs (ug/kg)	American Eel	Fillet	1999-2001	7	7	100%	1,624	745	670	2,800
	American Eel	Fillet	2009-2010	32	32	100%	1,185	882	310	4,900
	American Eel	Whole Body	1999-2001	6	3	50%	810	710	75	1,700
	American Eel	Whole Body	2009-2010	19	19	100%	1,849	1,681	670	7,500
	Blue Crab	Hepatopancreas	1999-2001	15	15	100%	5,513	1,958	3,200	11,000
	Blue Crab	Hepatopancreas	2009-2010	7	7	100%	3,300	1,233	1,200	5,100
	Blue Crab	Muscle	1999-2001	18	4	22%	64	22	16	75
	Blue Crab	Muscle	2009-2010	21	19	90%	31	27	3.5	100
	Blue Crab	Whole Body (Soft Tissue)	1999-2001	19	19	100%	777	467	140	1,800
	Blue Crab	Whole Body (Soft Tissue)	2009-2010	41	41	100%	473	277	110	1,300
	White Perch	Fillet	1999-2001	6	6	100%	842	179	600	1,100
	White Perch	Fillet	2009-2010	19	19	100%	551	298	190	1,300
	White Perch	Whole Body	1999-2001	18	18	100%	3,989	1,821	1,200	10,000
	White Perch	Whole Body	2009-2010	19	19	100%	2,308	1,124	470	4,200

Notes: Includes all samples collected in the river. The 1999-2001 sampling events include the 1999 Late Summer/Early Fall RI-ESP Sampling Program, the 2000 Spring RI-ESP Sampling Program, and the 2001 Supplemental RI-ESP Biota Sampling Program. The 2009/2010 sampling period includes samples collected by the CPG during that period. 1/2 detection limit substituted for non-detected values. Field duplicate results were averaged. Total PCB concentrations are the sum of 7 Aroclors.

Table 2. Tissue Concentrations in Selected Species Collected in LPRSA River Mile 0 to 8

Chemical	Species	Tissue Type	Sampling Period	N	Number of Detects	Frequency of Detection	Mean	Standard Deviation	Minimum	Maximum
2,3,7,8-TCDD (ng/kg)	American Eel	Fillet	1999-2001	7	7	100%	21.7	6.49	14.6	32.2
	American Eel	Fillet	2009-2010	16	16	100%	14.9	9.91	4.70	41
	American Eel	Whole Body	1999-2001	6	6	100%	9.7	6.34	4.53	20.6
	American Eel	Whole Body	2009-2010	8	8	100%	24.8	13.2	5.70	47
	Blue Crab	Hepatopancreas	1999-2001	15	15	100%	262	45.0	195	371
	Blue Crab	Hepatopancreas	2009-2010	5	5	100%	176	34.4	130	210
	Blue Crab	Muscle	1999-2001	18	18	100%	17.6	3.94	10.9	22.7
	Blue Crab	Muscle	2009-2010	11	11	100%	11.10	5.23	3.80	20
	Blue Crab	Whole Body (Soft Tissue)	1999-2001	19	19	100%	75.0	24.8	28	141
	Blue Crab	Whole Body (Soft Tissue)	2009-2010	22	22	100%	61.6	22.1	24	110
	White Perch	Fillet	1999-2001	6	6	100%	64.9	22.2	34.4	88.9
	White Perch	Fillet	2009-2010	11	11	100%	48.9	22.5	22.0	99
	White Perch	Whole Body	1999-2001	18	18	100%	212	81.1	73.6	352
	White Perch	Whole Body	2009-2010	10	10	100%	158	45.8	73.0	250
Total PCBs (ug/kg)	American Eel	Fillet	1999-2001	7	7	100%	1,624	745	670	2,800
	American Eel	Fillet	2009-2010	16	16	100%	1,271	1086	450	4,900
	American Eel	Whole Body	1999-2001	6	3	50%	810	710	75	1,700
	American Eel	Whole Body	2009-2010	8	8	100%	2,780	2,299	760	7,500
	Blue Crab	Hepatopancreas	1999-2001	15	15	100%	5,513	1,958	3,200	11,000
	Blue Crab	Hepatopancreas	2009-2010	5	5	100%	3,900	725	3,200	5,100
	Blue Crab	Muscle	1999-2001	18	4	22%	64	22	16	75
	Blue Crab	Muscle	2009-2010	11	11	100%	40	30	17	100
	Blue Crab	Whole Body (Soft Tissue)	1999-2001	19	19	100%	777	467	140	1,800
	Blue Crab	Whole Body (Soft Tissue)	2009-2010	22	22	100%	477	353	110	1,300
	White Perch	Fillet	1999-2001	6	6	100%	842	179	600	1,100
	White Perch	Fillet	2009-2010	11	11	100%	649	319	190	1,300
	White Perch	Whole Body	1999-2001	18	18	100%	3,989	1,821	1,200	10,000
	White Perch	Whole Body	2009-2010	10	10		2,630	748	1900	4,200

Notes: Includes only samples collected below LPRSA river mile 8. The 1999-2001 sampling events include the 1999 Late Summer/Early Fall RI-ESP Sampling Program, the 2000 Spring RI-ESP Sampling Program, and the 2001 Supplemental RI-ESP Biota Sampling Program. The 2009/2010 sampling period includes samples collected by the CPG during that period. 1/2 detection limit substituted for non-detected values. Field duplicate results were averaged. Total PCB concentrations are the sum of 7 Aroclors.

Table 3. Results of Power Calculations Using Tissue Data from the LPRSA (RM 0 to 8)

Chemical	Species	Tissue Type	Sampling Period	N[a]	Mean	SD	Mean Difference	Number of Samples (α = 0.1; β = 0.70)[b]
2,3,7,8-TCDD (ng/kg)	American Eel	Fillet	1999-2001	7	21.7	6.49	6.8	13
			2009/2010	16	14.9	9.91		
	Blue Crab	Hepatopancreas	1999-2001	15	262	45.0	86	2
			2009/2010	5	176	34.4		
		Edible Muscle	1999-2001	18	17.6	3.94	6.5	3
			2009/2010	11	11.10	5.23		
		Whole Body (Soft Tissue)	1999-2001	19	75.0	24.8	13	22
			2009/2010	22	61.6	22.1		
	White Perch	Fillet	1999-2001	6	64.9	22.2	16	17
			2009/2010	11	48.9	22.5		
		Whole Body	1999-2001	18	212	81.1	54	4
			2009/2010	10	158	45.8		
Total PCBs (ug/kg)	American Eel	Fillet	1999-2001	7	1,624	745	354	--
			2009/2010	16	1,271	1086		
	Blue Crab	Hepatopancreas	1999-2001	15	5,513	1,958	1613	1
			2009/2010	5	3,900	725		
		Edible Muscle	1999-2001	18	64	22	23	12
			2009/2010	11	40	30		
		Whole Body (Soft Tissue)	1999-2001	19	777	467	300	6
			2009/2010	22	477	353		
	White Perch	Fillet	1999-2001	6	842	179	193	54
			2009/2010	11	649	319		
		Whole Body	1999-2001	18	3,989	1,821	1359	2
			2009/2010	10	2,630	748		

Notes:

a) Number of samples from LPRSA RM 0-8.

b) Number of samples needed to detect a significant difference using a one-sided t-test with a probability of 70% at an alpha of 0.10 assuming that the sample size of the first group is equal to the 2009/2010 sample size.

-- Indicates sample size is incalculable.